



BROWN

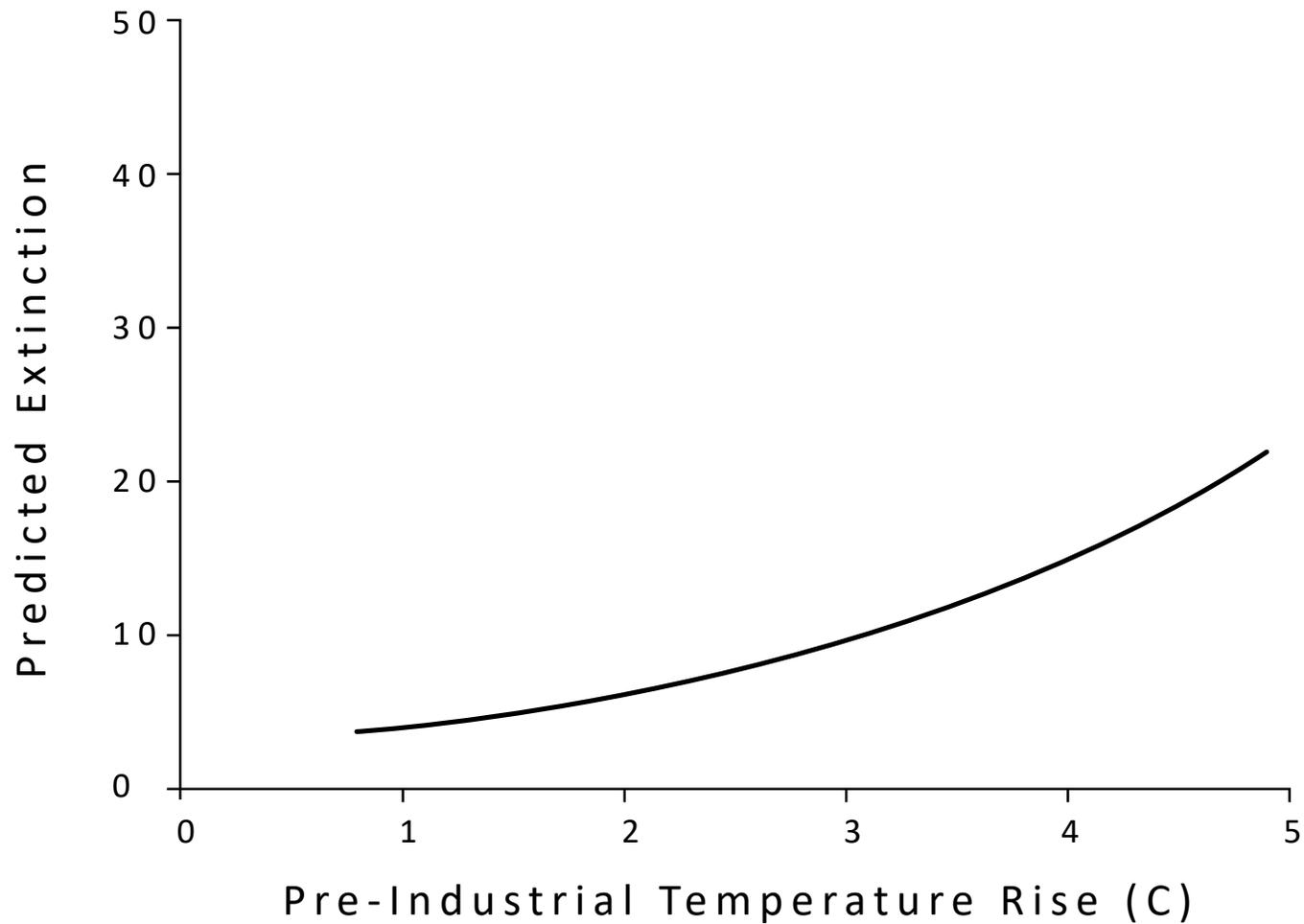
Assessing Risks from Climate Change to Federally- Listed Plant Species

Dov Sax, Brown University
Jesse Bellemare, Smith College
Regan Early, University of Exeter

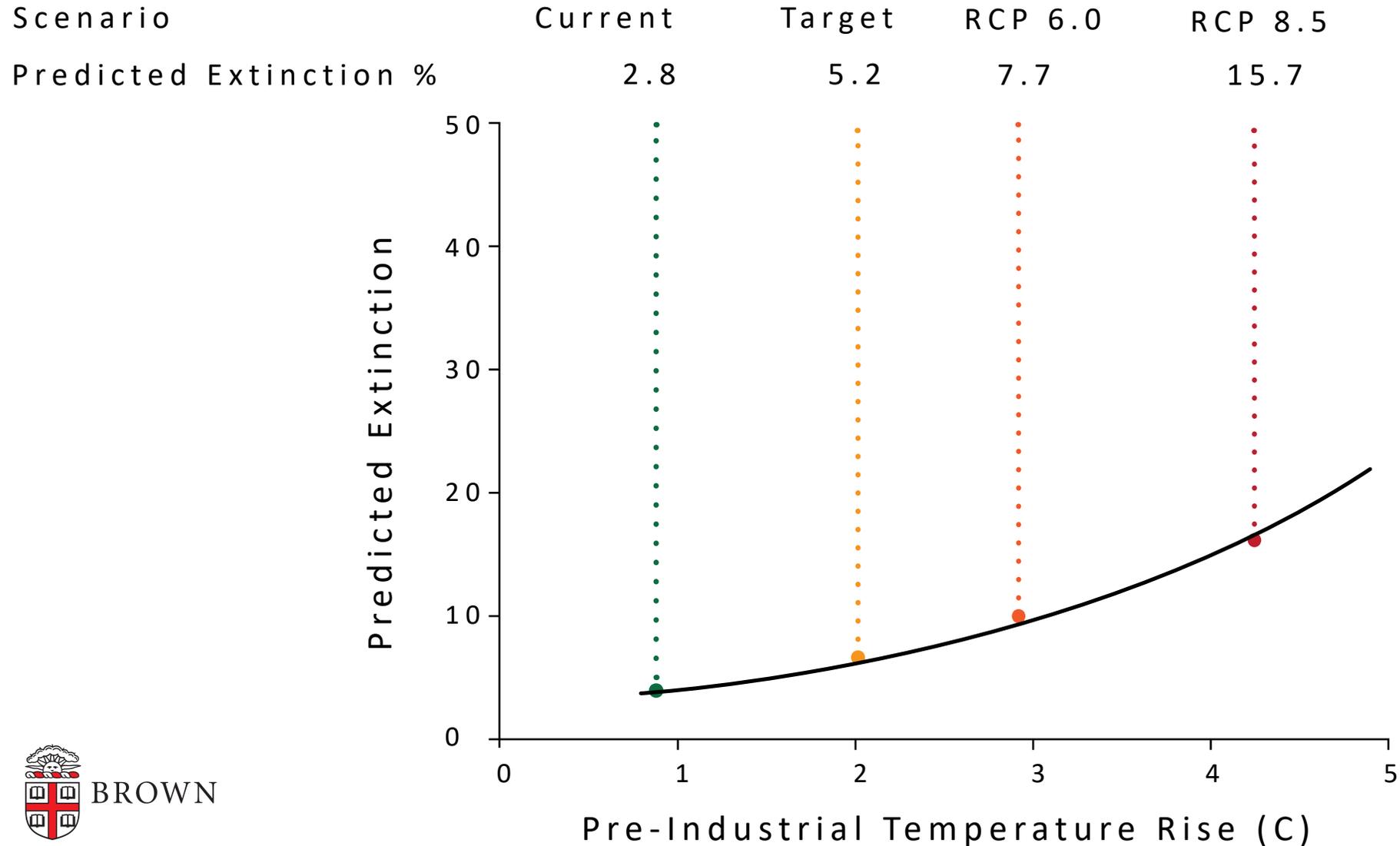


SERDP • ESTCP
SYMPOSIUM
2019 | Enhancing DoD's Mission Effectiveness

Meta-analysis: Climate Change and Extinction Risk



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Climate Change and Extinction Risk

Global Risk:

5-15% of species at risk

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~ 9 million species globally

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450,000 - 1.35 million

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~ 16,000 species in lower-48

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Species at Risk of Extinction:

800 - 2,400

Why do we expect so many extinctions?

What's the big deal about 4 degrees?

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How much colder was the last ice-age?

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5 degrees

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Radically different world!

21,000 years ago – 5 degrees cooler



- Ice sheets covered the north



21,000 years ago – 5 degrees cooler



- Ice sheets covered the north
- Sea level lower – walk to Asia



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- Ice sheets covered the north
- Sea level lower – walk to Asia
- Great lakes existed in the West



How did species respond?

Three options:

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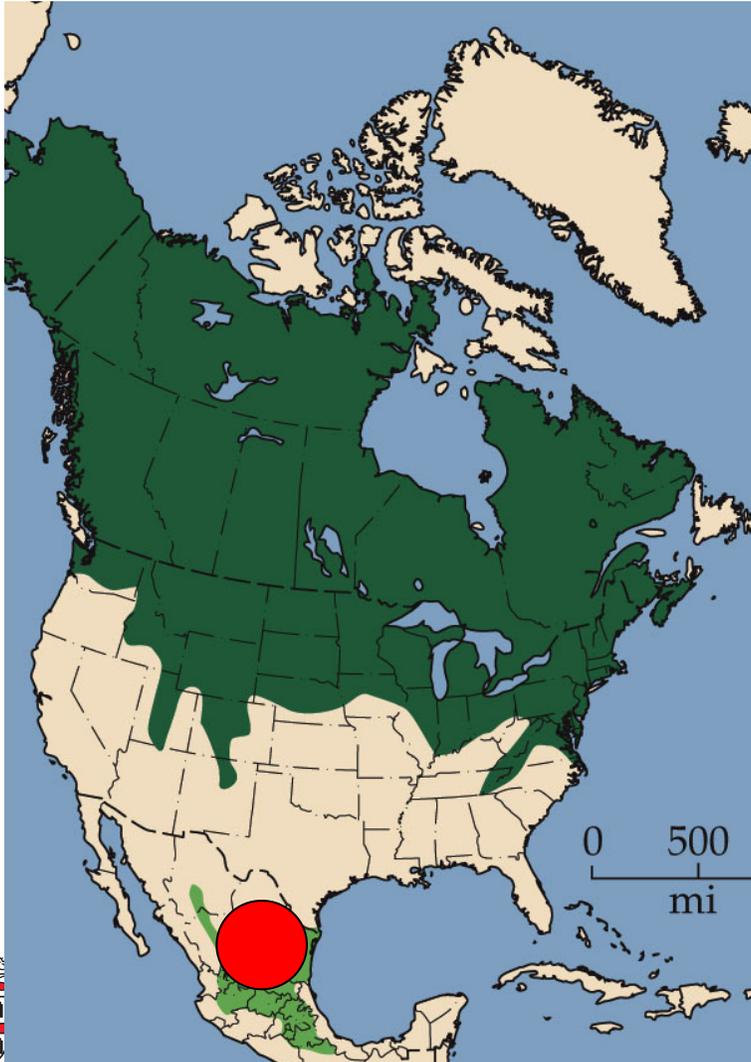
1) Die out and go extinct

How did species respond?

Three options:

- 1) Die out and go extinct
- 2) Tolerate or adapt to conditions
- 3) Move somewhere else

Adapt in place vs. move a long, long way



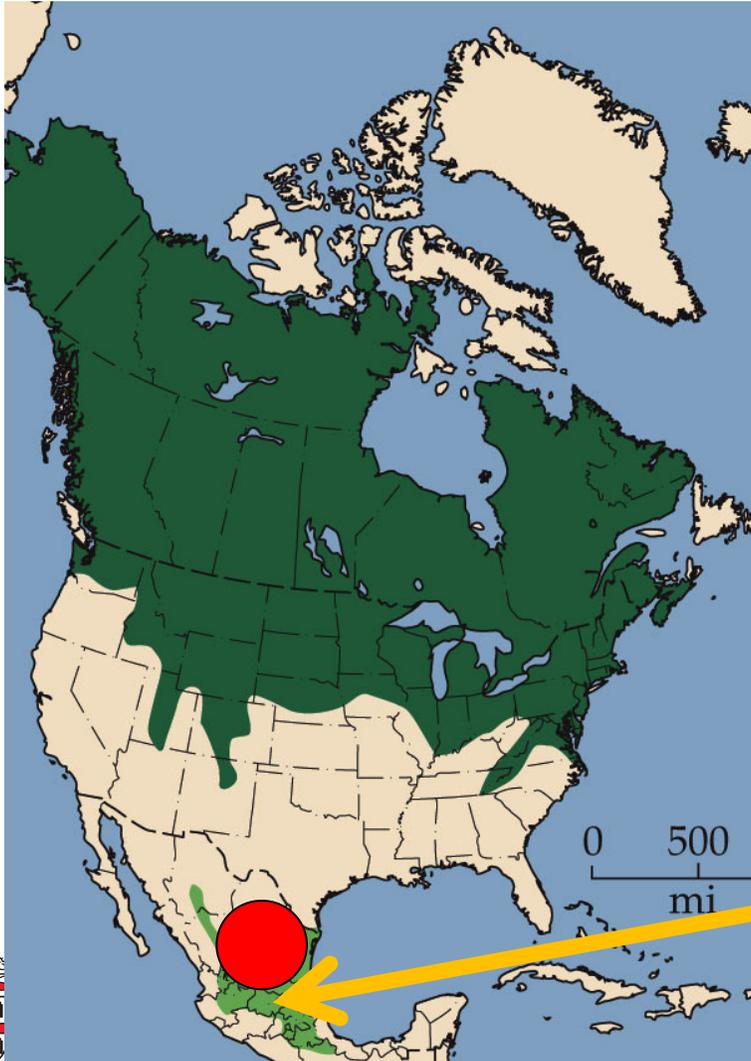
Masked shrew



Pocket mouse



Adapt in place vs. move a long, long way



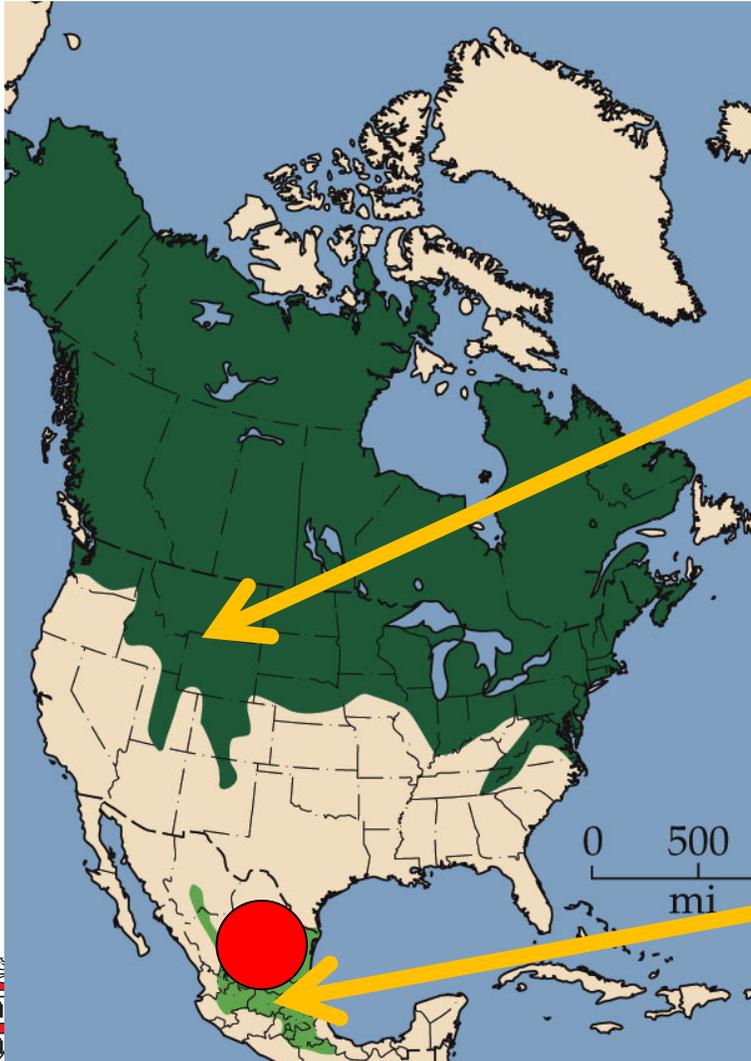
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Climate Change and Species Extinction Risk

Crux of the problem – we don't know which species are at risk

Climate Change and Species Extinction Risk

Crux of the problem – we don't know which species are at risk

- Don't know what new species will be at risk
- Don't know what currently endangered species at risk

Project Goal

- Develop a predictive framework for estimating risk for plants in the contiguous USA
- Apply that framework to federally-listed species on DoD installations

Project Approach

- Explore climate conditions that species can tolerate beyond those experienced in their native ranges

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 - Planted and surviving without care – evidence of tolerable conditions

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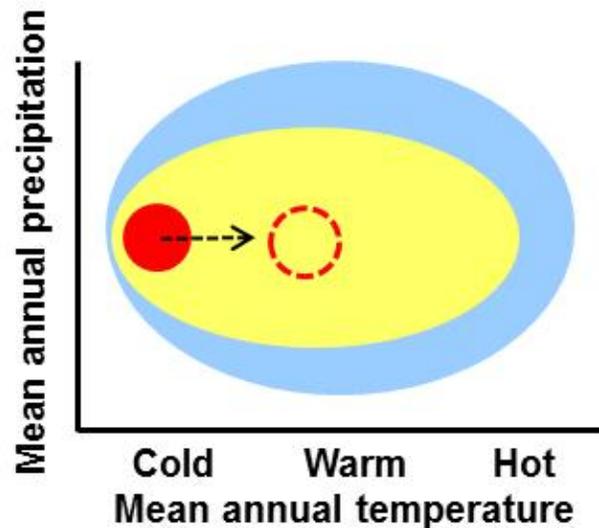
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- Relate that broader tolerance to species traits
 - Range size, dispersal syndrome, growth form, habitat type, etc.

Conceptual Overview – Climate Space Configurations

Implications if climate warms for species on military installations
Many possible scenarios – but three alternatives are presented here

Conceptual Overview – Climate Space Configurations

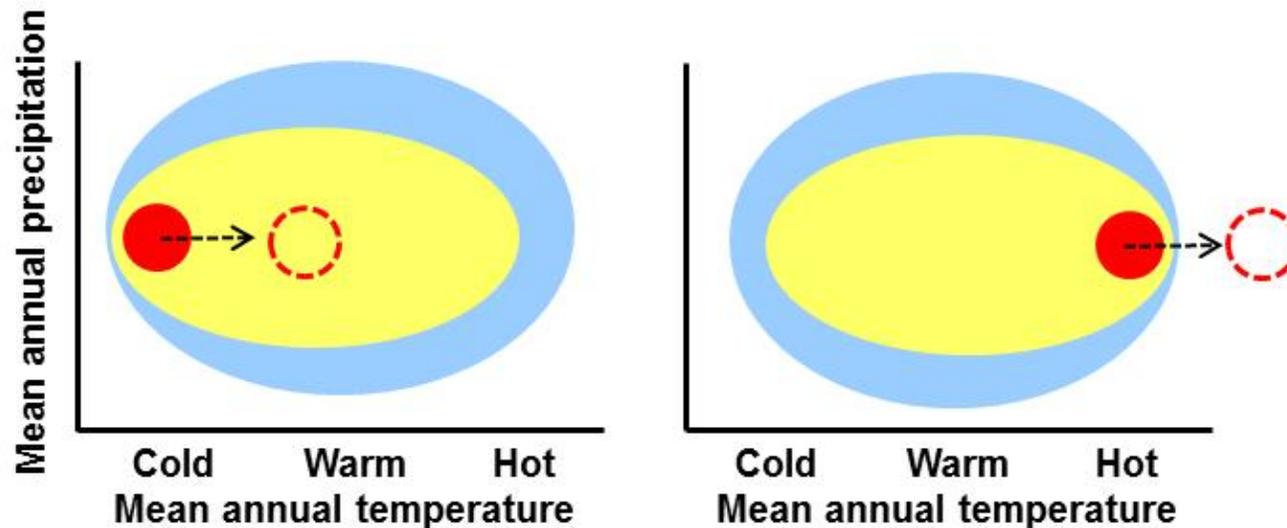
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Risk - low

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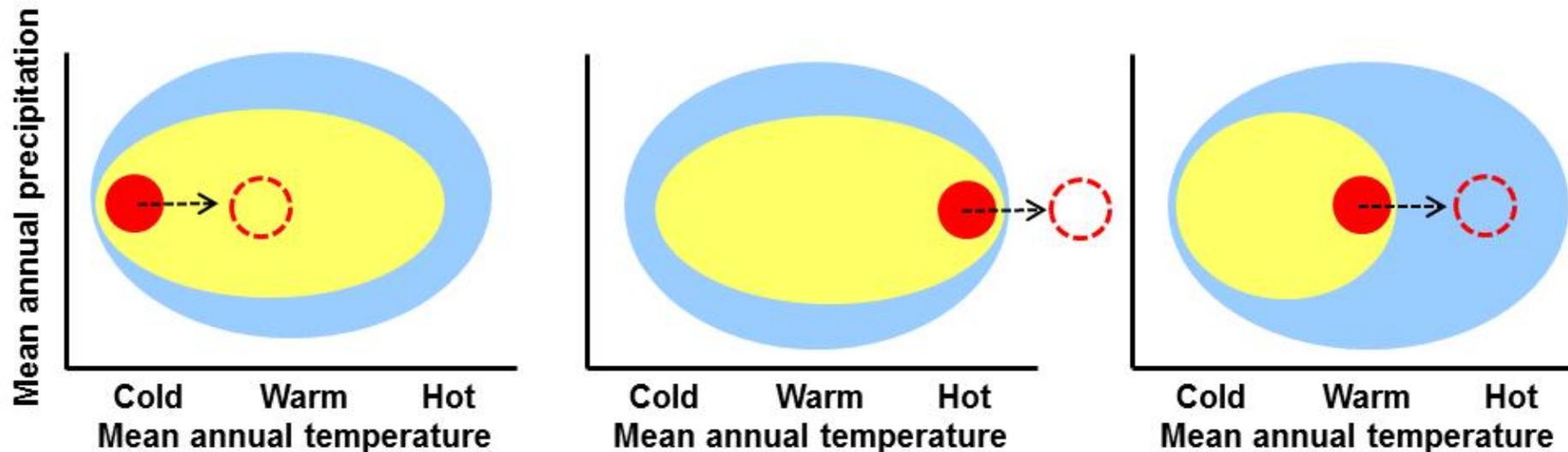


Risk - low

Risk - high

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Risk - low

Risk - high

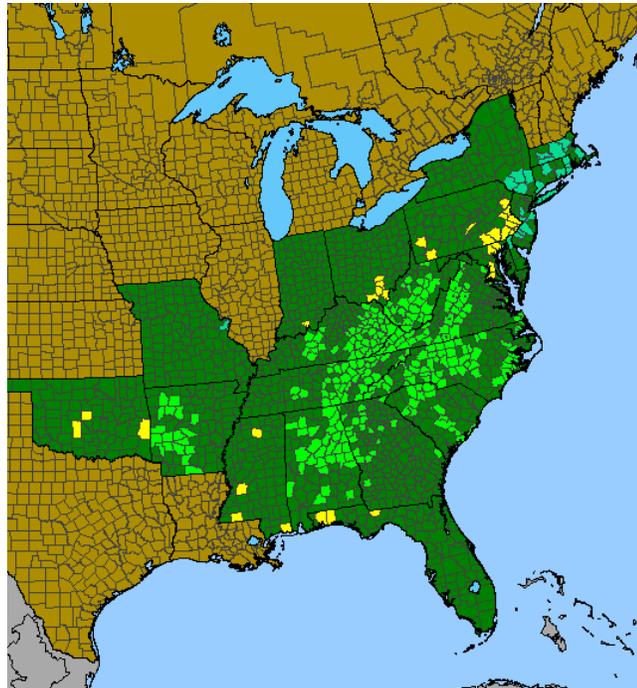
Risk - delayed

Study Species

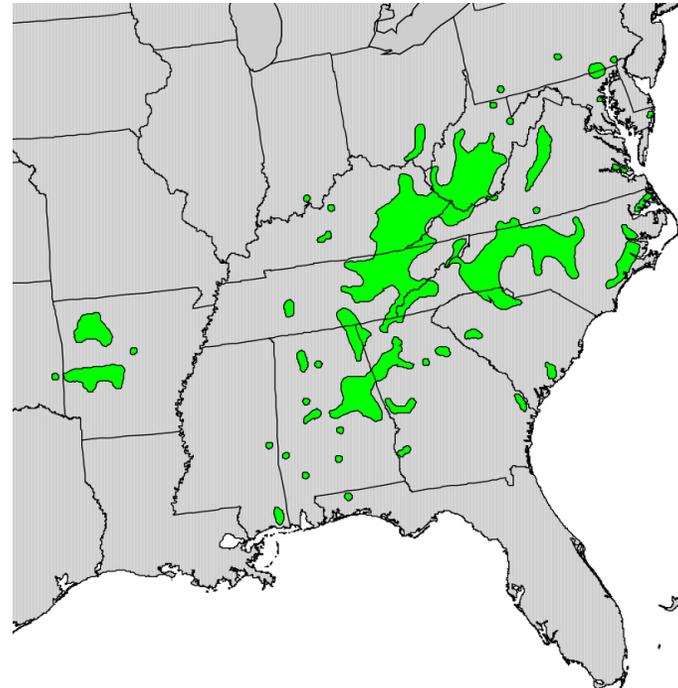
- 200 species native to USA, but naturalized outside their range
- 1000 species picked at random from contiguous USA flora
 - 460 species federally-listed from contiguous USA

Data Sources – Native Range

Biota of North
America Program



Forest Service

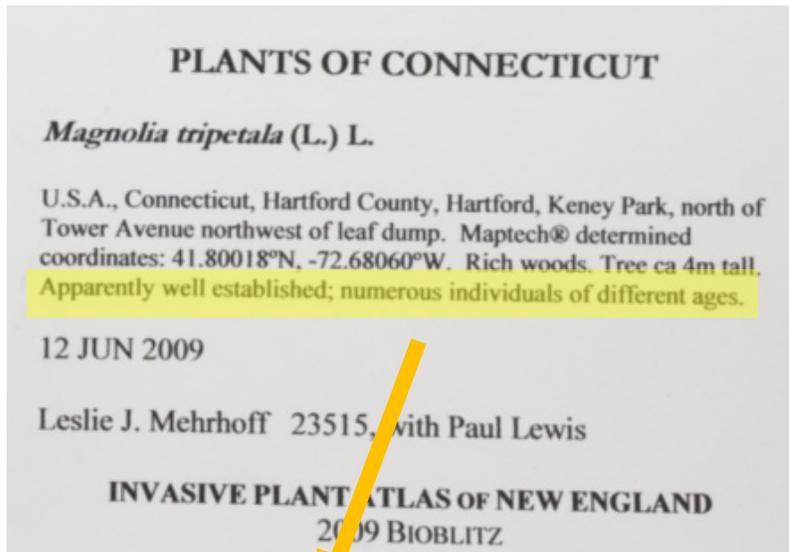


Literature Accounts
– state by state

Botany was popular
in the 1800's, so
good historical
records available

Data Sources – Naturalized Range

Plant Herbaria –
digitized specimen labels



“well established; numerous
individuals of different ages”



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Field Visits –
More than 600 sites
(across the USA)



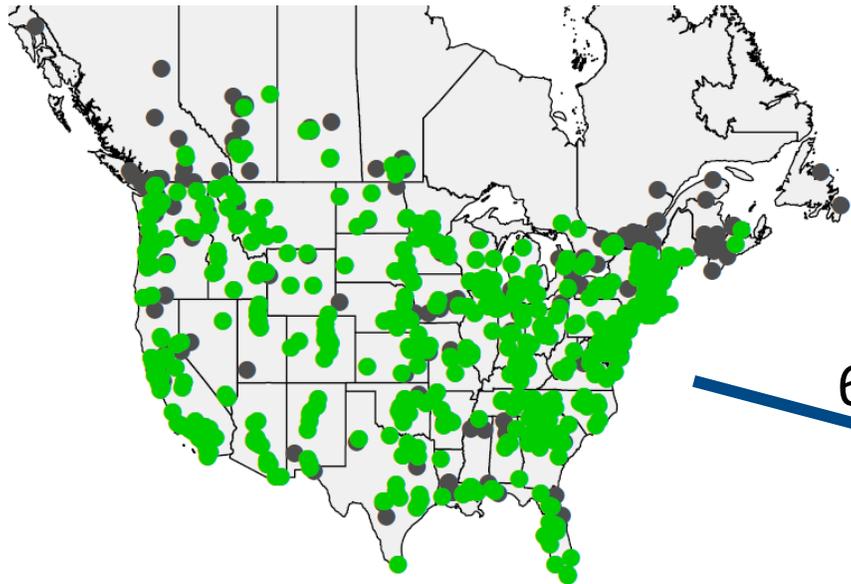
Use visits to calibrate how
we interpret herbarium
specimens



More than 8,000
occurrence points for
our target species
that are wild or
naturalized

Data Sources – Horticultural Range

800 Plant Nurseries



650 interviews

100 Botanical Gardens

67 Surveys

20,000+ data points

General Findings – Part I

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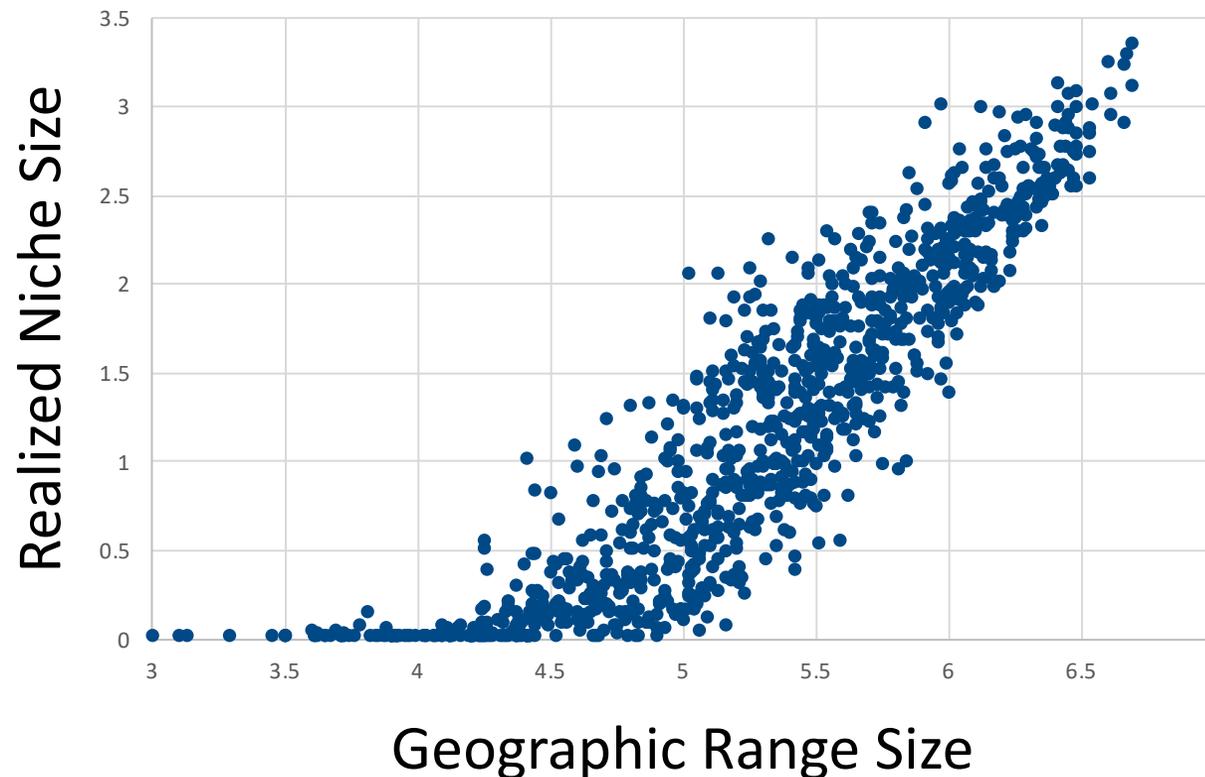
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- 85% of species naturalized outside native range, do so in conditions beyond those occurring in native range
 - expansion of the native climate niche is common

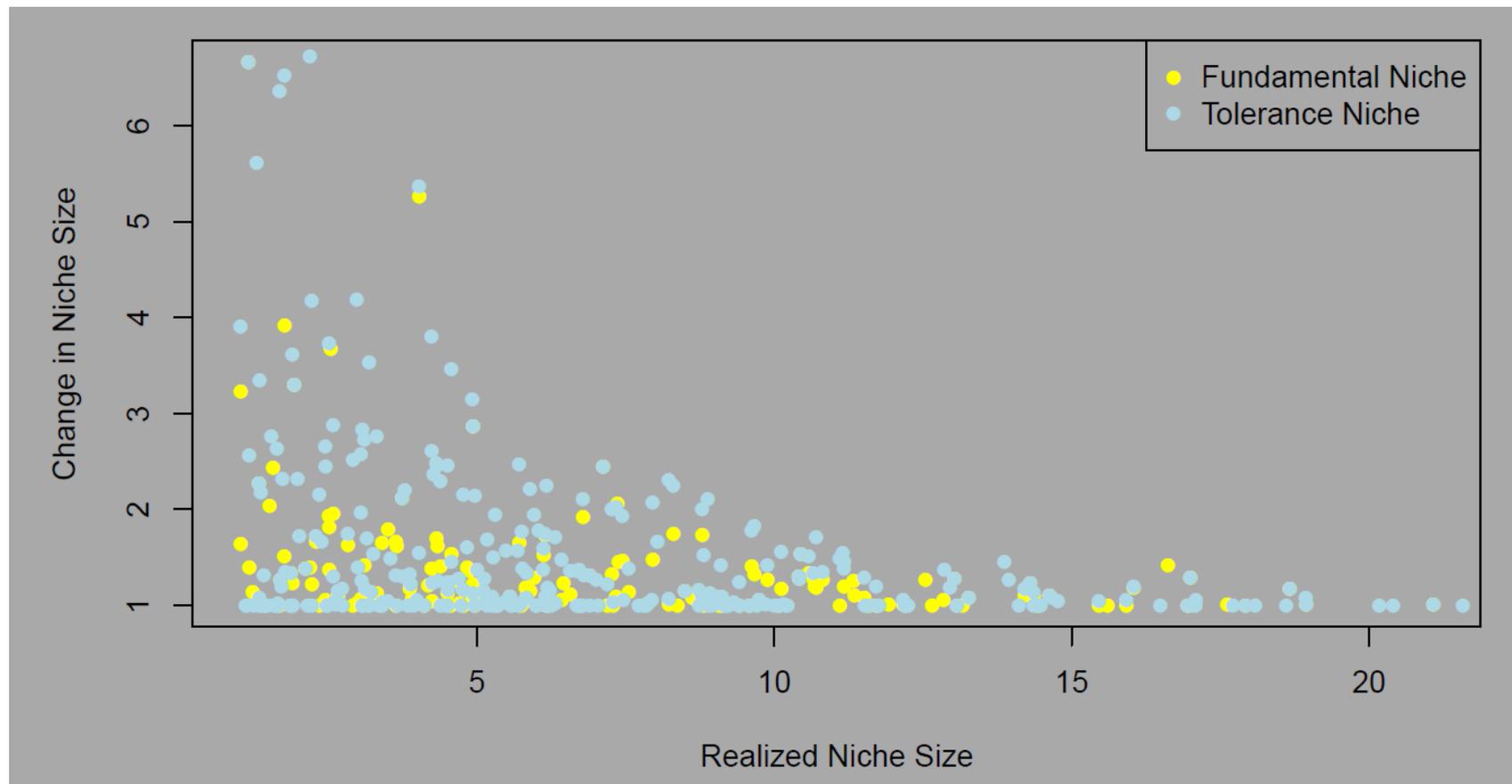
General Findings – Part II

Geographic range size is correlated with the extent of climate conditions experienced in the native range (aka realized niche)



General Findings – Part III

Species with small niches (and small ranges) show the largest increases in climate space occupied outside their native ranges



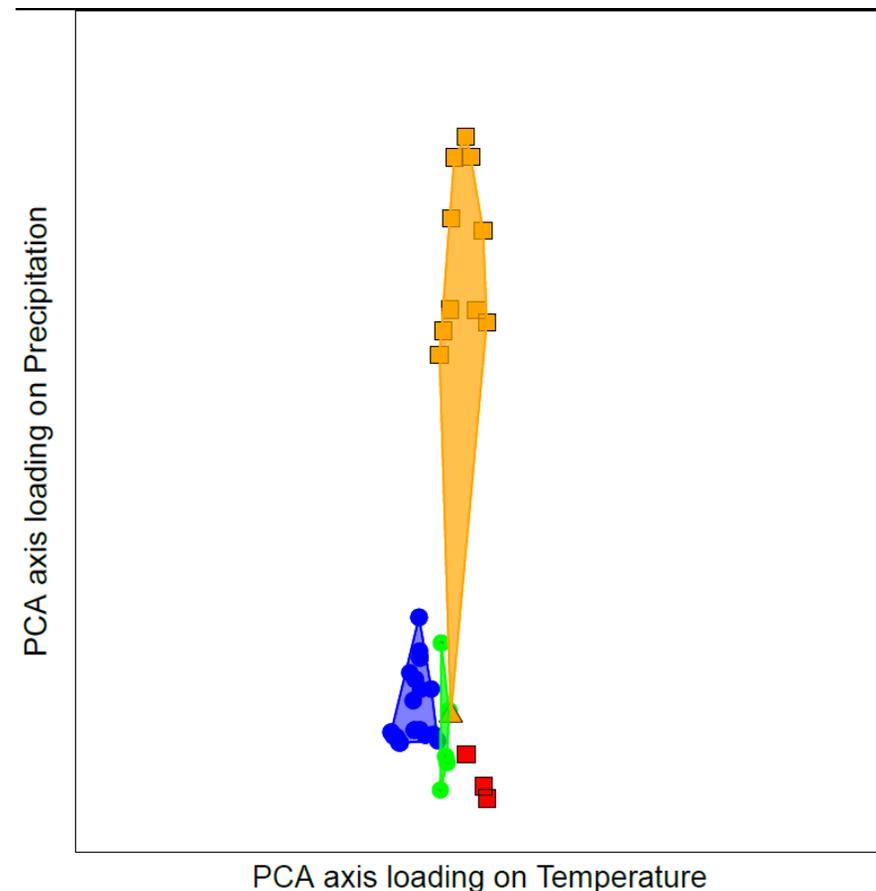
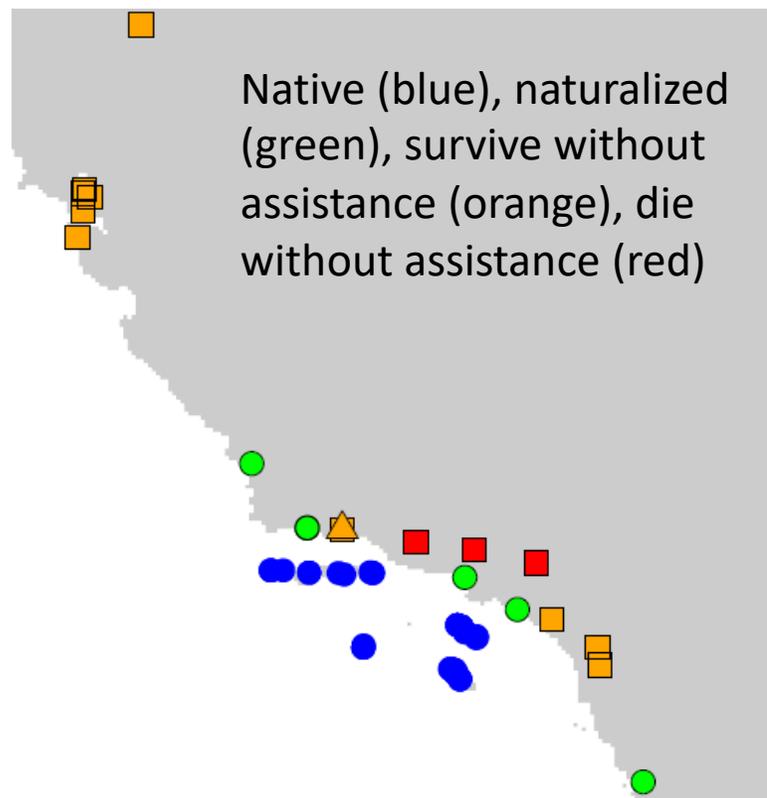
General Findings – Part IV

Many small-ranged species not closely limited by climate

Island Mallow
(*Malva assurgentiflora*)



- Small native range
- Tolerates substantially warmer and dryer conditions



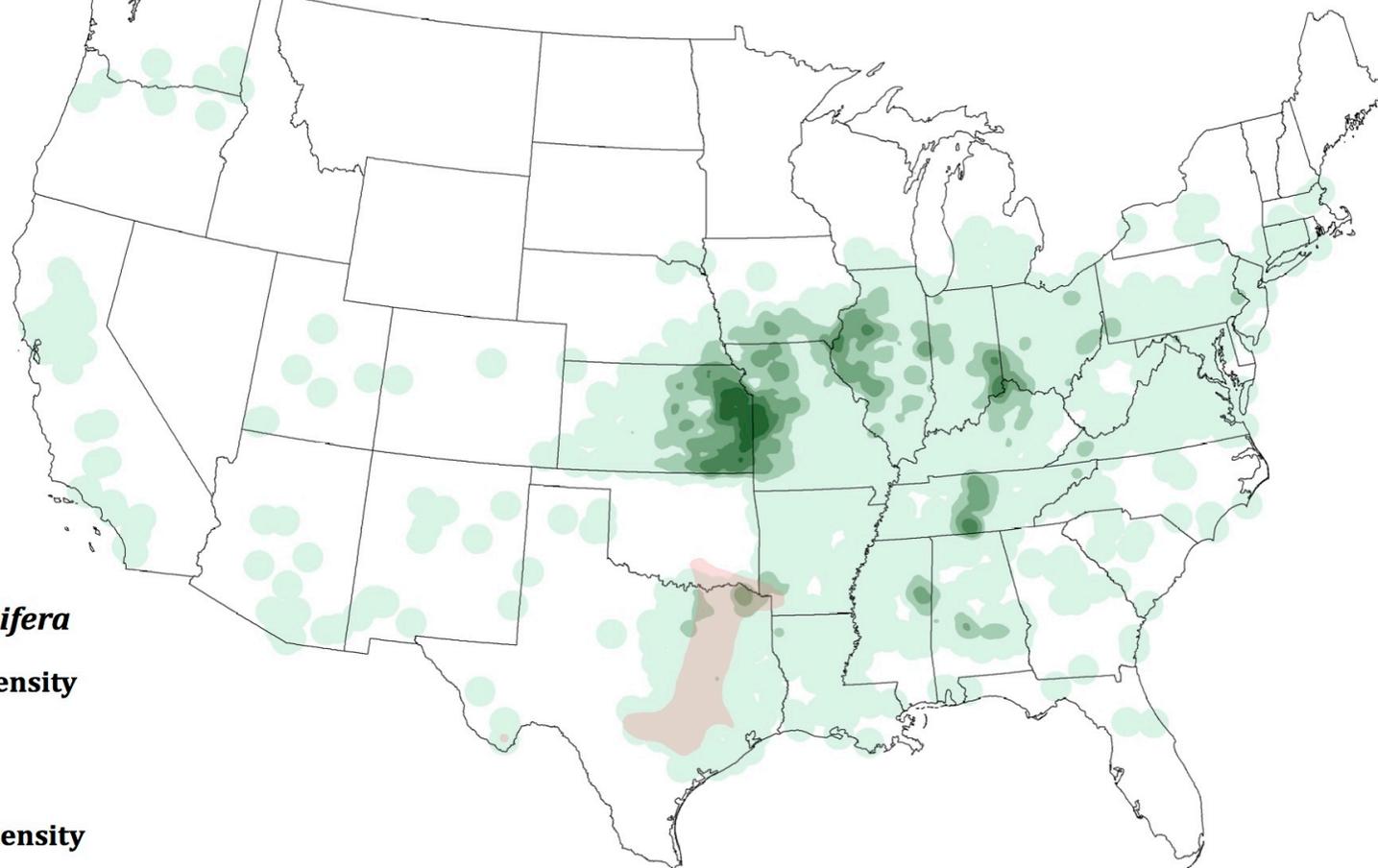
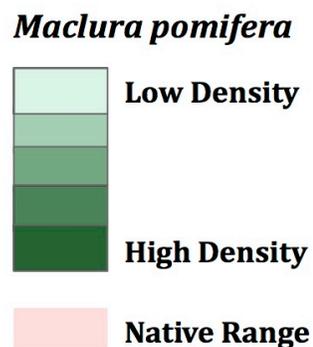
General Findings – Part IV

Many small-ranged species not closely limited by climate

Osage orange (*Maclura pomifera*)



Small native range
Enormous naturalized range
Specialized for fruit dispersal
by extinct megafauna



0 200 400

General Findings – Part V

Species with the largest consistent increases in climate space occupied outside their native ranges are ones specialized for dispersal by now extinct megafauna

Kentucky Coffeetree



Osage Orange



Black Locust



General Findings – Part VI

Species with the no apparent mechanism for dispersal, classified as being dispersed by “gravity”, often show a large expansion of climate conditions beyond the native range

Island Mallow



Monterey Cypress



Mock Orange



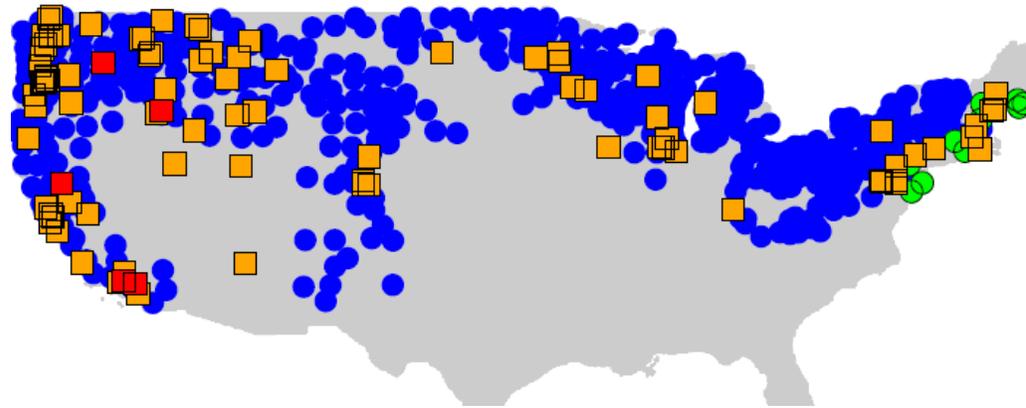
General Findings – Part VII

Large-ranged species often closely limited by climate

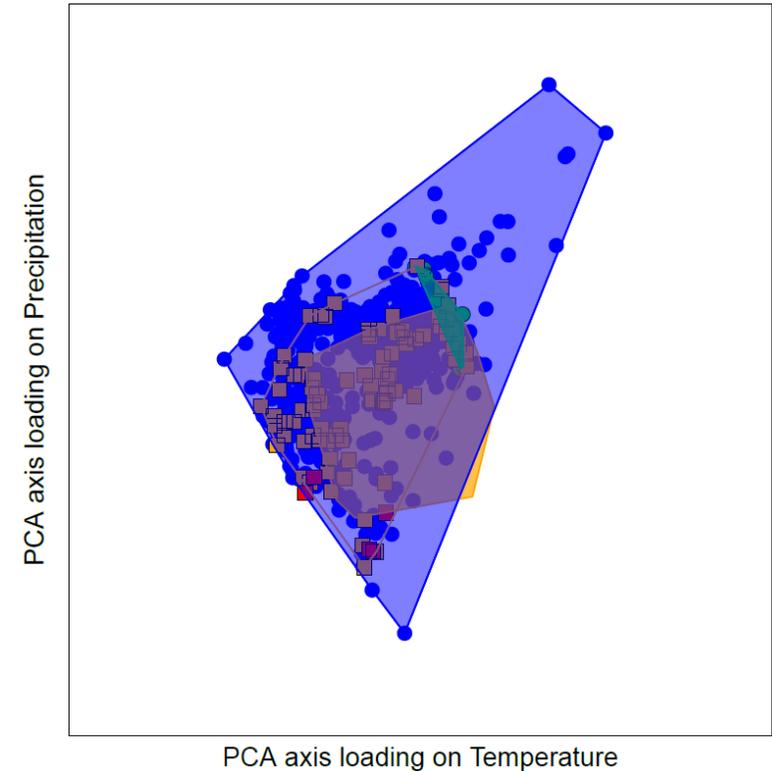
Symphycarpus albus



Almost all non-native occurrences are within native climate conditions



Native (blue), naturalized (green), survive without assistance (orange), die without assistance (red)



General Findings – Part VIII

Expansion into climate conditions beyond those in the native range occur in both warmer and cooler conditions, but are most common into cooler conditions

Findings – Endangered Species

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We have the least direct evidence of endangered plant species tolerance for climate – as a group they have only recently been brought into horticulture and sold commercially.

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But we still have enough data to help inform risk.

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As a group – endangered plant species show the most capacity to expand to climate conditions beyond those in the native range.

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- Dispersal limited

(over-represented by “gravity” and “ant” dispersal,
under-represented by “bird” and “mammal” dispersal)

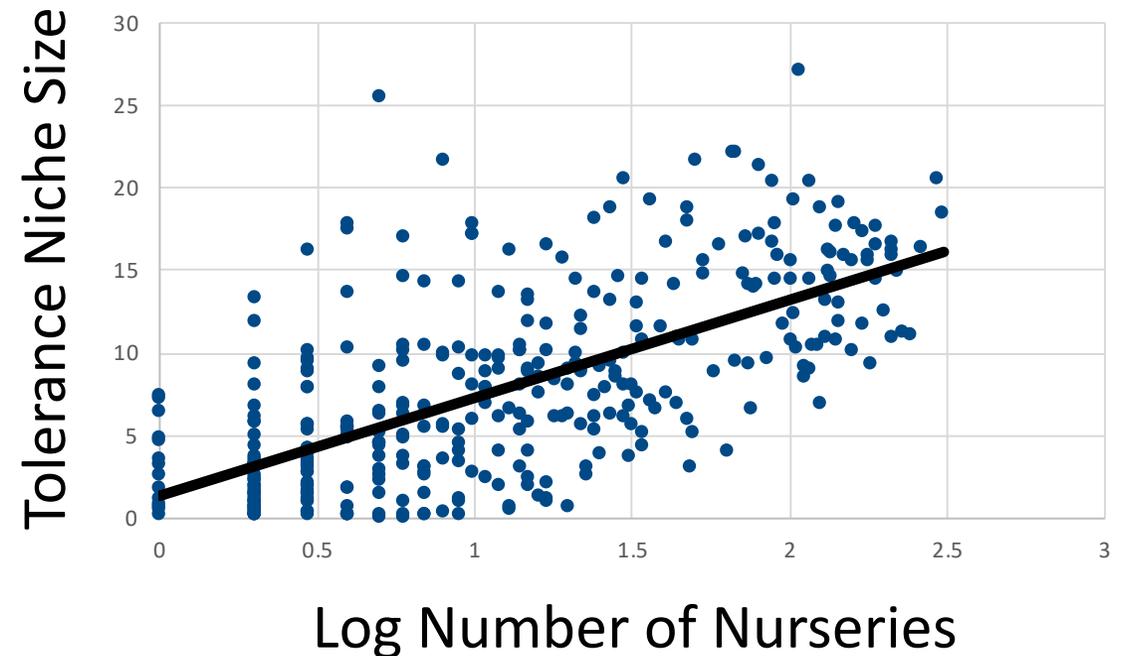
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When we do have evidence of niche expansion with endangered species, its important to remember that it's a minimum estimate

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Strong, positive linear relationship between number of nurseries and estimate of extent of climate conditions that can be tolerated



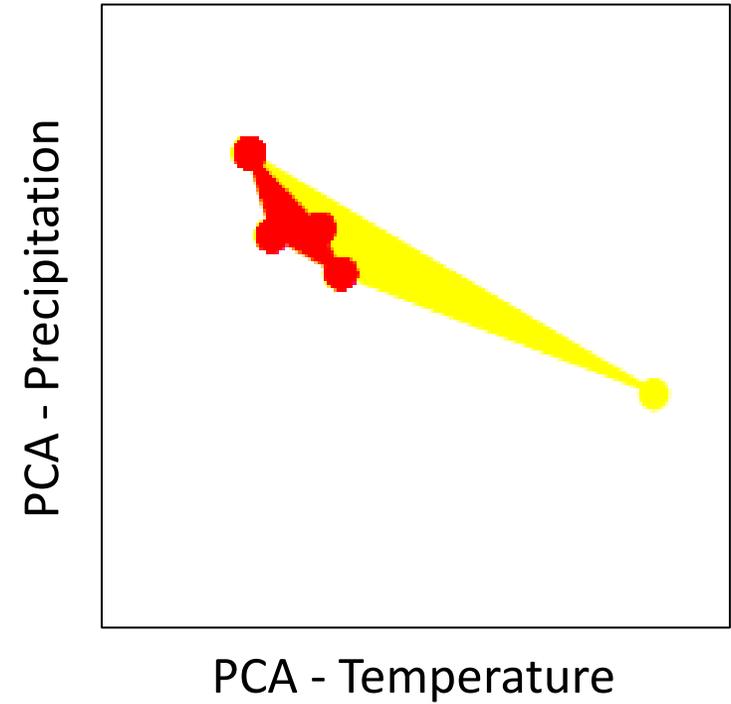
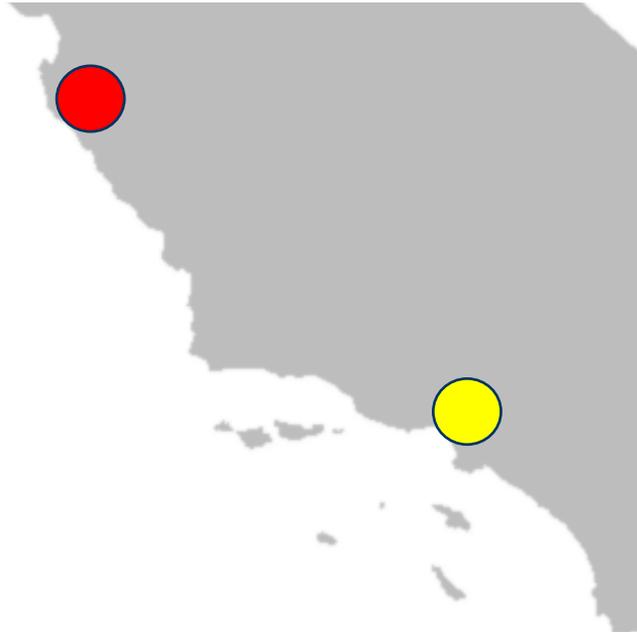
Findings – Endangered Species

Some thrive in warmer conditions – unlikely to be directly impacted by climate change

Californian cypress
(*Hesperocyparis goveniana*)



Native to Monterey,
naturalized near Los Angeles



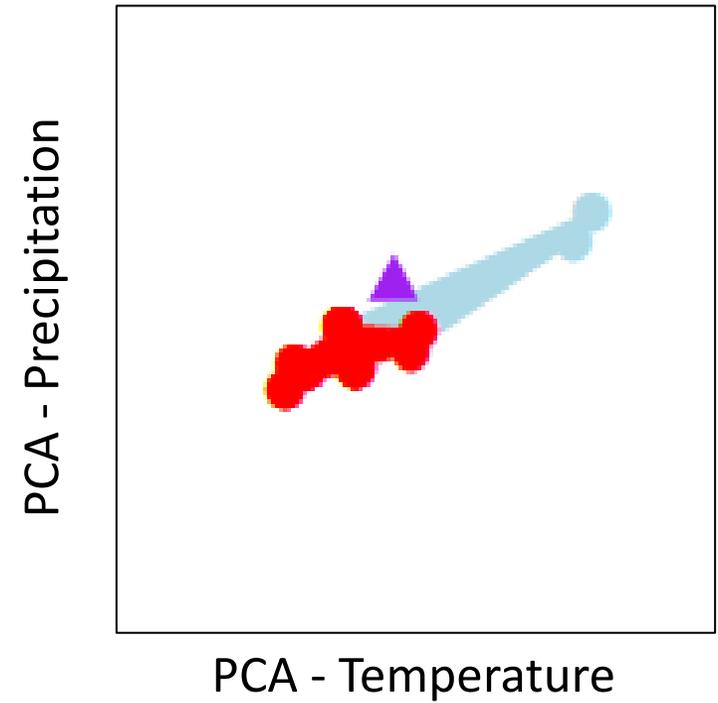
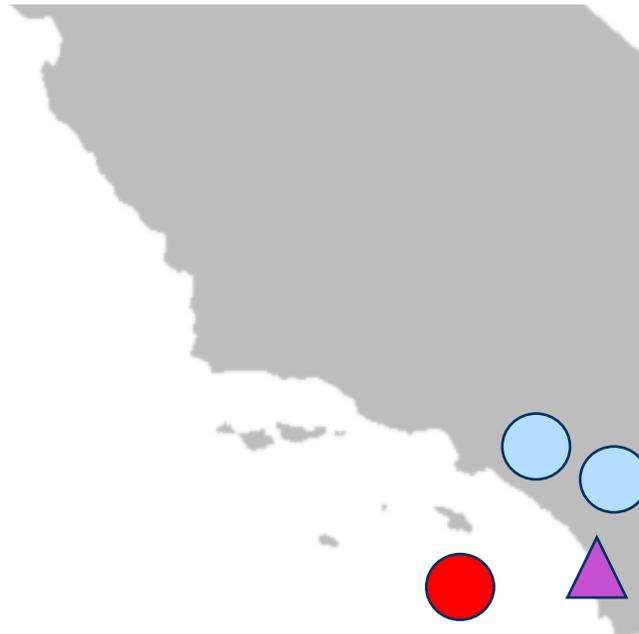
Findings – Endangered Species

Some tolerate warmer conditions, but are close to a climate limit

San Clemente bushmallow
(*Malacothamnus clementinus*)

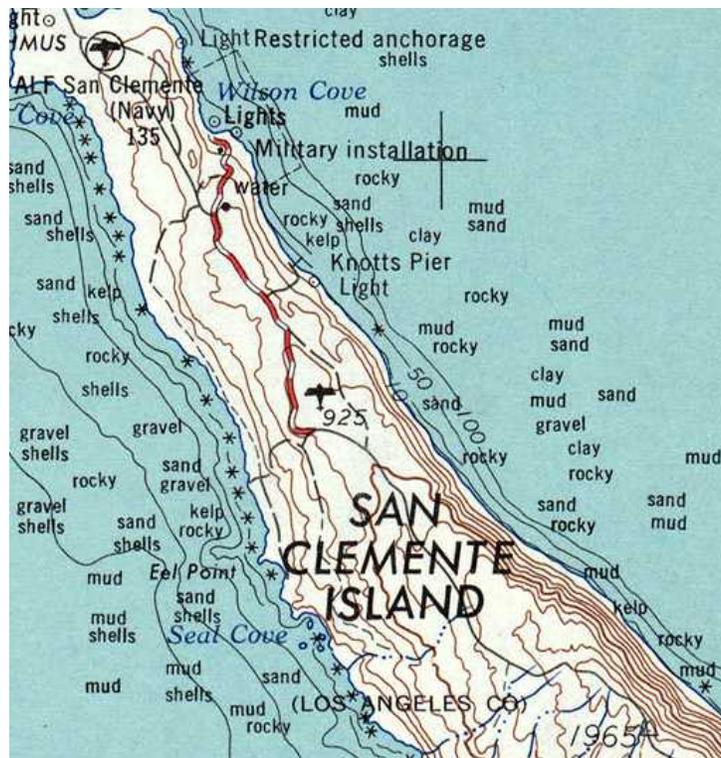


Endemic to San Clemente Is.



Findings – Endangered Species

Given the topographic relief of San Clemente Island & the bushmallow's robustness to some warming, this species is at low additional threat from changes in climate



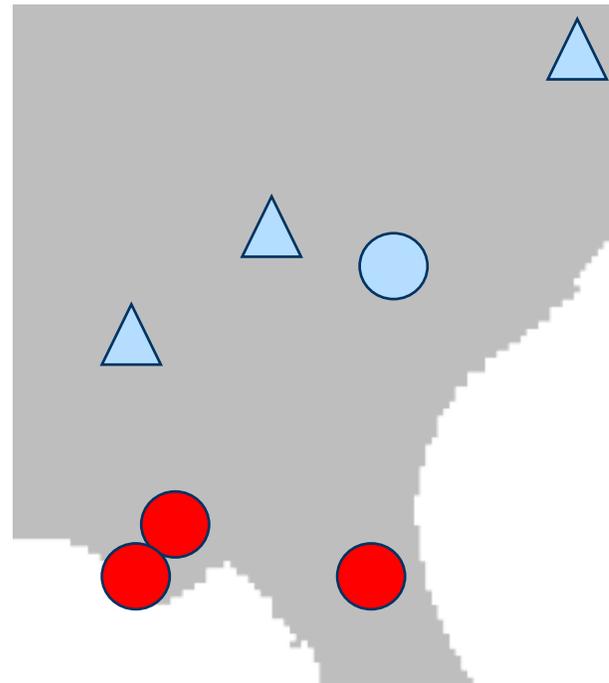
Findings – Endangered Species

Some show expansion, but no evidence of tolerance for warmer conditions

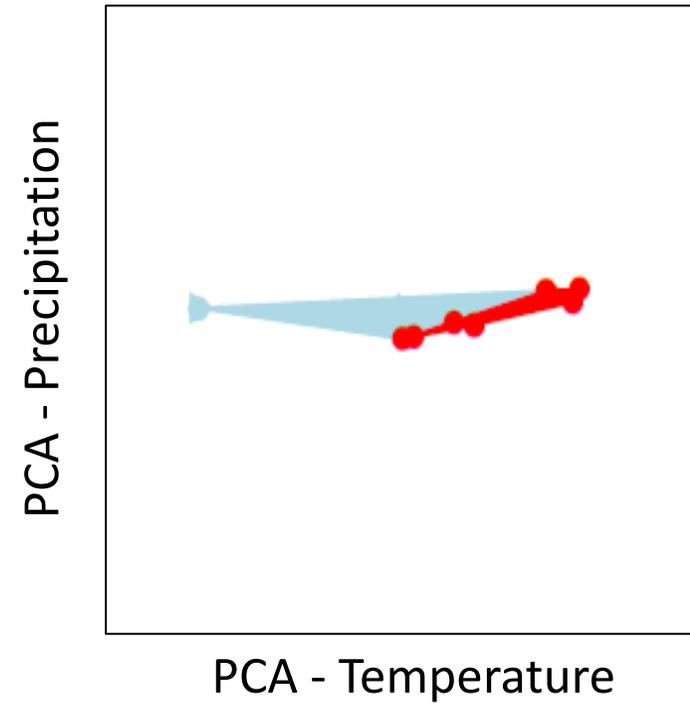
Chapman's Rhododendron
(*Rhododendron chapmanii*)



Occurs on a military installation in Florida



61



Next Steps – Endangered Species

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- Relate species distribution models to forecasts of climate conditions in 2050 and 2070
- Contextualize vulnerabilities of these species to climate change
- Deliver broader project findings, as well as species-specific findings to interested parties, including biologists at relevant installations

Final Thought –

*Unmanaged relocation
of populations is already
occurring*

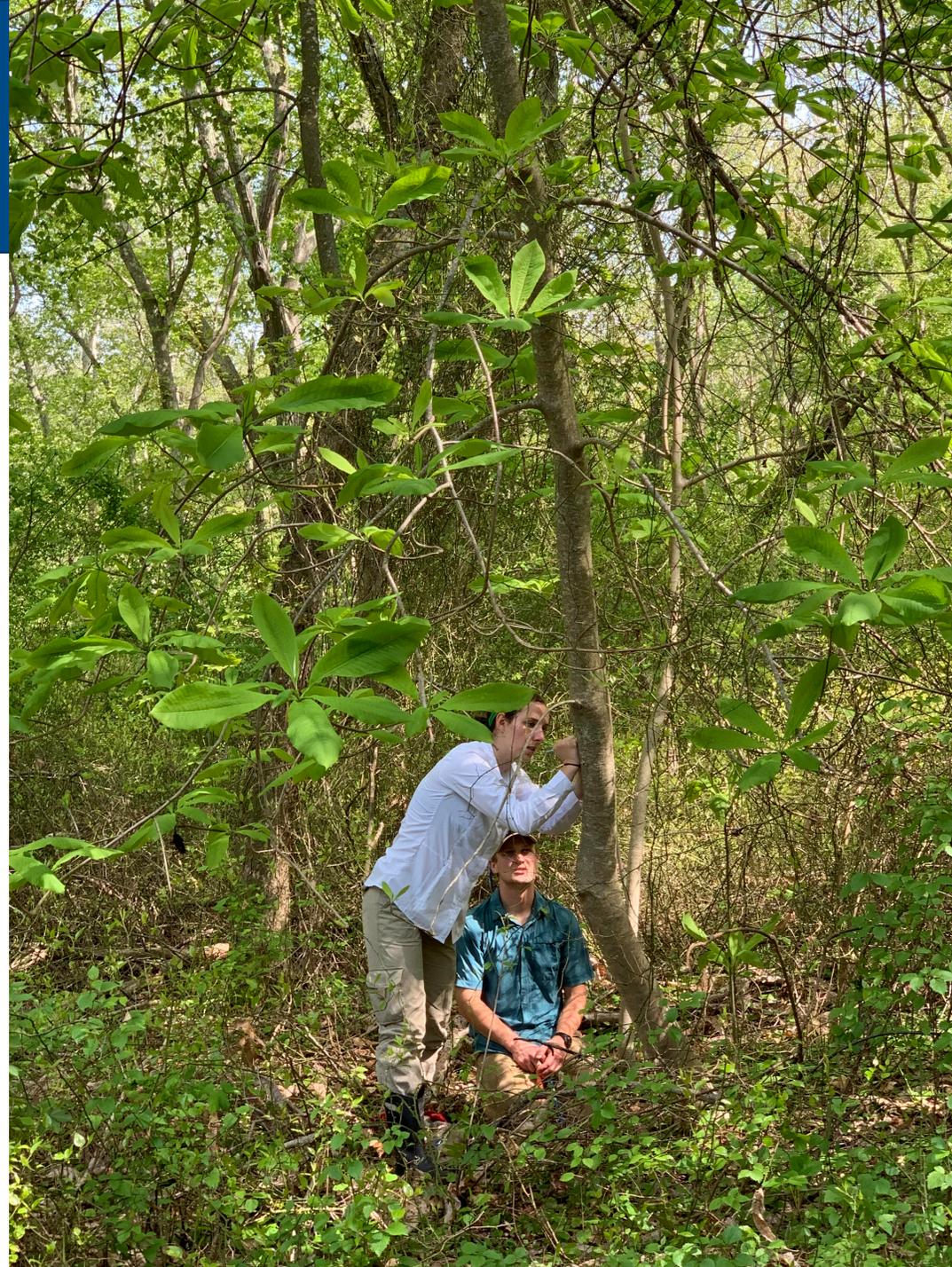
Magnolia tripetala

Escaped from
horticulture in RI

400km north of the
native range



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